Annual Project Summary

CENTRAL U.S. SHEAR WAVE VELOCITY DATABASE WITH ACCOMPANYING GEOLOGICAL/GEOTECHNICAL INFORMATION OF NONLITHIFIED GEOLOGIC MATERIALS

External Grant Award Number 04-HQ-GR-0074

Robert A. Bauer, Coordinator CUSEC State Geologists, Illinois State Geological Survey, Champaign, Illinois 61820

Telephone (217)244-2394 FAX (217) 244-2785 bauer@isgs.uiuc.edu

Technical Abstract

The proposed project is to collect shear wave velocity measurements of nonlithified geologic materials along with their lithologic descriptions and geotechnical properties for the cooperative earthquake hazard mapping in St. Louis Urban Hazard Mapping and the Tri-State (Evansville) Urban Hazard Mapping area of Indiana, Kentucky and Illinois. This will ultimately produce a region-specific relationship between lithologies and seismic wave velocities for use in production of soil profile type derivative maps. This will be performed by collecting existing shear wave velocity and corresponding lithologic and geotechnical information, measuring in situ shear wave velocities in materials and areas where no or few values exist, and collecting lithologic and geotechnical data at new shear wave velocity sites.

NON-TECHNICAL SUMMARY

The Central U.S. Earthquake Consortium (CUSEC) State Geologists are gathering information on the local geologic and material properties of the soils in the cooperative earthquake hazard mapping areas of St. Louis Urban Hazard Mapping and the Tri-State (Evansville) Urban Hazard Mapping area of Indiana, Kentucky and Illinois. The information gathered will be used to first produce geologic maps of the materials resting on the bedrock of these areas at a scale of 1:24,000 or 1 inch = 2,000 feet. The geologic map along with measurements of the soil's properties are used to classify the various soils as to how much they would amplify earthquake ground motions. The amplification maps can be used in the Federal Emergency Management Agency's earthquake loss estimation program (HAZUS) to better estimate the amount of damages a community may expect from various earthquakes.

Investigations undertaken

Illinois Geological Survey

Downhole shear wave velocity measurements were made in two 100 + foot deep boreholes in the Mississippi River floodplain near Horseshoe Lake in Illinois where nearly the entire column of materials are sand. The work near Horseshoe Lake was performed in the Monks Mound quadrangle which is part of the St. Louis Urban Hazard Mapping project. Also a 182 foot deep borehole had downhole shear wave velocity measurement performed along with a 1 mile long shear wave reflection survey. The second set of work was performed just north of Lebanon, Illinois where a valley cut into the bedrock crosses the area.

Indiana Geological Survey

The Indiana Geological Survey had several shear wave velocity reflection lines run on both the east side and west side of Evansville, Indiana, within the Evansville Urban Hazard Mapping area. These locations compliment the 51 shear wave velocity measurements taken along with the cone penetrometer tests run by the USGS CPT truck during the fall of 2003. Additionally a collection of engineering boring records for the Evansville area have been secured and need to be inventoried for their location in the city.

Kentucky Geological Survey

In cooperation with the geologic mapping project in Henderson-Owensboro area, 20 sites have been selected for SH-wave refraction profiling to determine shear-wave velocities and subsurface. Four sites have been completed. The surficial geologic mapping has identified four major soil units: modern fluvial deposits, young terrace, old terrace, lake deposits. Based on the walk away tests and field conditions, a single or multiple spreads of SH-wave refraction profile will be used to characterize the major soil units and the depth to bedrock. The data will be collected with an EG and G StrataVisor, 24-bit, 48-channel, floating-point, engineering seismograph. The energy source for SH-wave generation was a 0.3-m section of steel I-beam struck horizontally by a sledgehammer, and the signal receivers are 30-Hz horizontal component geophones from Mark Products. For each shotpoint, signals were stacked two to five times on each direction (reversed) of the energy source. Geophone spacing is 2 meters. The data will be processed on a PC using the commercial software package SIP 4.0 by Rimrock Geophysics VISTA 7.0 by Seismic Image Software.

The field data collection started in mid-September and will be finished in October 2004. The preliminary results show a good correlation with surfacial geology. Figure 1 show the shear-wave velocity profile collected along Rockport Ferry Road in Owensboro, Kentucky.

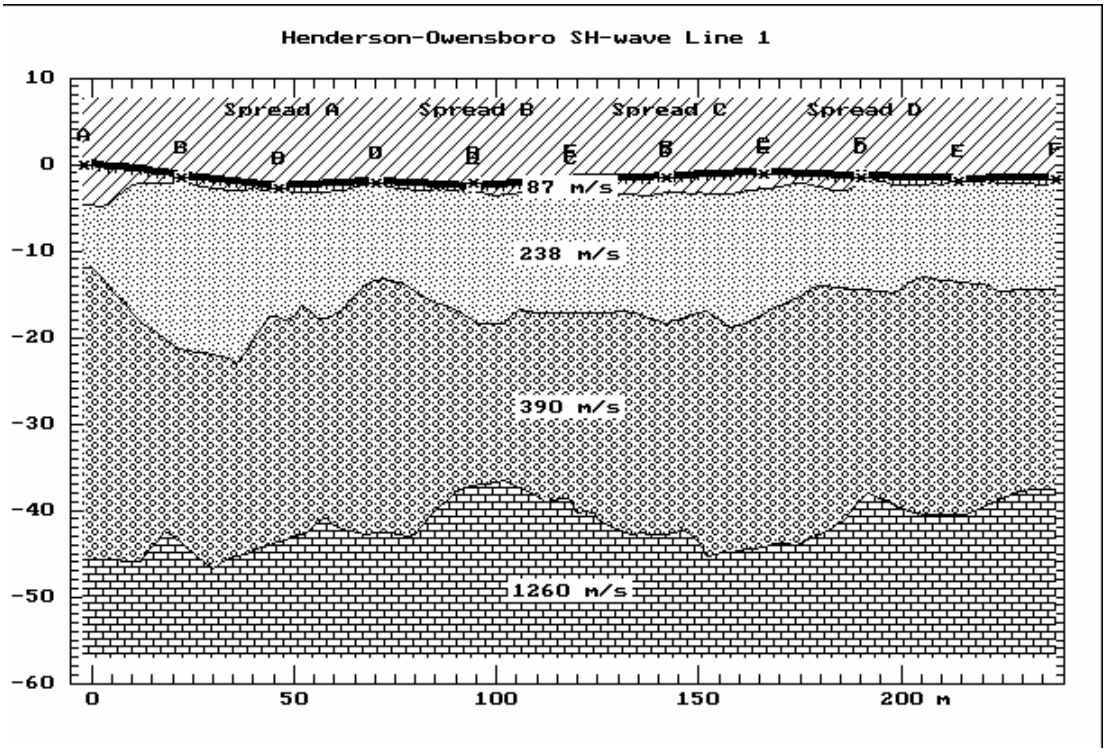

Figure 1. Shear wave reflection line in Evansville Urban Hazard Mapping area – in Kentucky.

Missouri Geologic Survey

The chief NEHRP related activity completed in Missouri was a seismic soil amplification map for a four quadrangle area centered on Poplar Bluff in southeastern Missouri (Hoffman, 2004). This map used existing geologic and surficial material mapping and collected new shear-wave data. Of these shear wave data sets, 18 sites in alluvial settings were tested with the generous assistance of the Missouri Department of Transportation using a seismic cone penetrometer. The seismic cone penetrometer could not be used in upland settings with very stony, bedrock residuum, soils. In these settings additional data were collected using surface geophysical techniques. One collaborative effort included the assistance from the Kentucky Geological Survey/University of Kentucky to collect shear wave data using a surface technique that employs shear waves at 10 sites. The University of Missouri at Rolla (UMR) was contracted to complete a second surface geophysical technique, a multi-channel analysis of surface waves (MASW) to derive 2-d shear-wave velocity profiles at 40 sites. Shear wave data collection tests using surface geophysical techniques can be used in any geological setting regardless of surficial material types. In all, the Poplar Bluff project had 58 separate and new shear wave tests at 40 sites.

A second campaign led to the collection of shear wave data at 20 additional sites in 10 eastern Missouri counties, including 11 sites in the St. Louis metropolitan area (figure 2). In this effort UMR was again contracted to conduct MASW geophysical surveys to

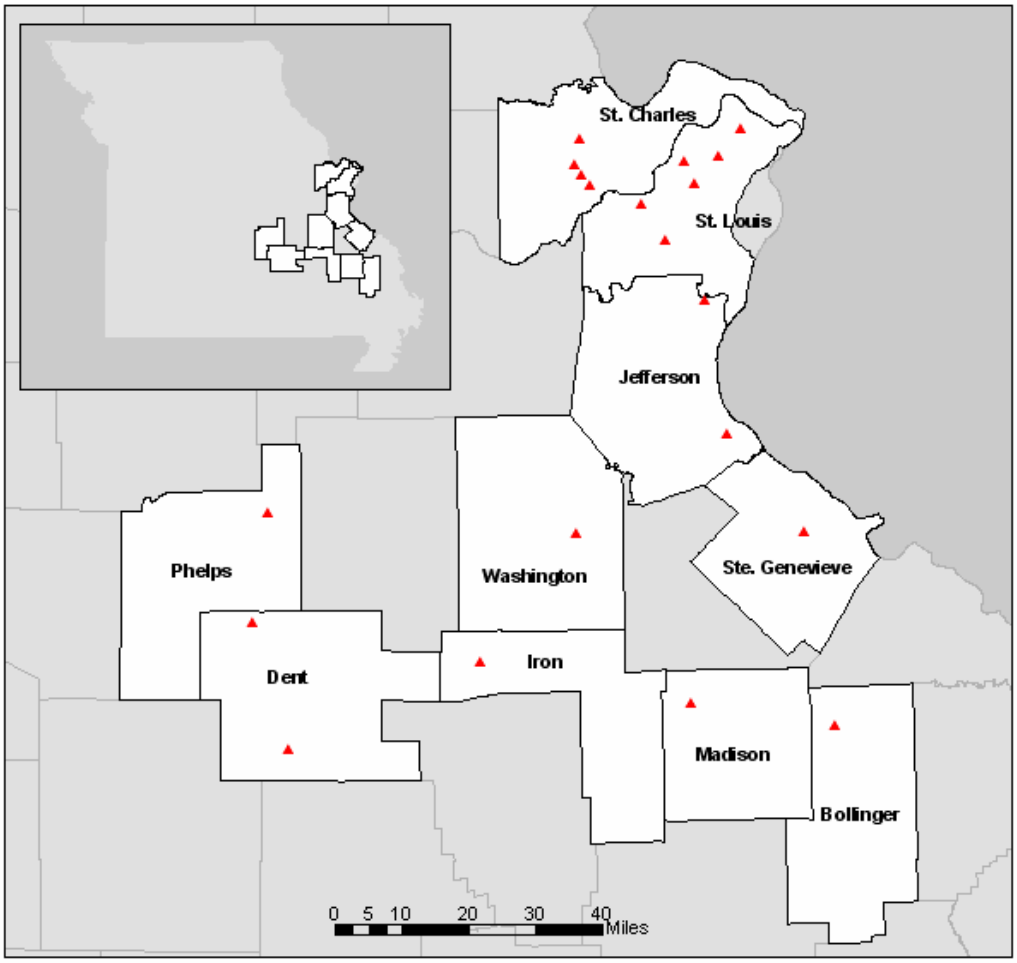

Figure 2. Shear-wave velocity sites in eastern Missouri collected during 2004, for the cusec state geologists NEHRP grant.

develop 2-dimensional shear wave profiles. The sites in the St. Louis area will be an important addition to the data needed to evaluate seismic hazards for the proposed St. Louis Urban Hazard Mapping Project.

Cooperation with USGS Seismic Cone Penetrometer Testing

During the late 2003 and 2004 the state geological surveys assisted with siting and utility clearance for Seismic Cone Penetrometer Testing of the USGS truck from the Menlo Park office. Fifty-one sites were tested in the Evansville area, three areas in the Vincennes, Indiana area of large paleoliquefaction features and one in Griffin, Indiana near other paleoliquefaction features from a coarse sand – gravel source.

Summary

The Central U.S. Earthquake Consortium (CUSEC) State Geologists are gathering geological information to first produce geologic maps of the materials resting on the bedrock at a scale of 1:24,000 or 1 inch = 2,000 feet in the cooperative earthquake hazard mapping areas of St. Louis Urban Hazard Mapping and the Tri-State (Evansville) Urban

Hazard Mapping area of Indiana, Kentucky and Illinois. The geologic map along with measurements of the soil's properties are used to classify the various soils as to how much they will amplify earthquake ground motions. The amplification maps can be used in the Federal Emergency Management Agency's earthquake loss estimation program (HAZUS) to better estimate the amount of damages a community may expect from various earthquakes. This work entails gathering all existing borehole information, "drilling" new holes for stratigraphy, measuring shear wave velocity leading to the production of new maps of the "soils" and their thickness. The average shear wave velocity is calculated for the total column of "soil" and used to produce a map classifying the soils as to how much they will amplify earthquake ground motions.

The data is mostly being assembled in paper copy until there is a consensus on a form of a database for the two urban hazard mapping areas and support is secured for extensive work on such a database.

References

Hoffman, David, 2004, Classification of soils for amplification induced by earthquake ground motions of the Poplar Bluff, Rombauer, Harviell & Hanleyville 7.5' quadrangles, Butler county, Missouri; 1:24,000 scale, Open-file Map, OFM-04-474-GS, Missouri Department Of Natural Resources Geological Survey And Resource Assessment Division Geological Survey Program